INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 3, No. 10, p. 306-311, 2013

RESEARCH PAPER OPEN ACCESS

Homeostasis model assessment of insulin resistance in response to aerobic program in adult obese women

Zahedmanesh Forouzan[1*], Pishkar Leila[2], Zahedmanesh Farnaz[1], Yousefi Soheila[1]

[1]*Department of Physical Education and Sport Science, Islamic Azad University, Islamshahr Branch, Islamshahr, Iran*

[2]*Department of Biology, Islamic Azad University, Islamshahr Branch, Islamshahr, Iran*

Key words: Insulin action, obesity, exercise.

doi: http://dx.doi.org/10.12692/ijb/3.10.306-311 Article published on October 21, 2013

Abstract

Physical activity is widely accepted that improve glucose homeostasis and insulin resistance in obese patient populations. This study was aimed to investigate the effect of a long term aerobic training on glucose profile and insulin action in obese women. For this purpose, pre and post aerobic training (3 per week / 12 weeks) blood samples were collected in fifteen adult obese women and compared with control group (no training) matched for age, gender, height, and BMI. Student's t-tests for paired samples were performed to determine whether there were significant within-group changes in the outcomes. A p-value less than 0.05 were considered statistically significant. At baseline there were no differences in the biochemical variables and anthropometrical parameters between the two groups. There was a decrease in fasting glucose levels and anthropometrical markers after exercise intervention. Compared to pre-training, serum insulin and insulin resistance decreased significantly after exercise program but not in the control group. Our results indicate that aerobic training for long time improves glucose homeostasis in obese men that is associated with improved insulin resistance.

* **Corresponding Author:** Zahedmanesh Forouzan ✉ foruzanzahedmanesh@yahoo.com

Introduction

It is generally accepted that major characteristic of type 2 diabetes are insulin resistance and insulin deficiency (DeFronzo *et al.,* 1992). On the other hand, a number of prospective population studies have found higher relation between type II diabetes and obesity or overweight. On the other hand, more recent reports indicate that obesity is the most critical factor in the emergence of metabolic diseases. In fact both obesity and type 2 diabetes are associated with insulin resistance. Although in obesity, insulin-resistant individuals do not develop hyperglycemia.

Insulin resistance (IR) is a condition in which the body's cells become resistant to the effects of insulin. That is, the normal response to a given amount of insulin is reduced. As a result, higher levels of insulin are needed in order for insulin to have its proper effects. In obese and insulin resistant individuals to be associated with type 2 diabetes, β-cells must be unable to compensate fully for decreased insulin sensitivity (Kahn, 2001). It has been previously reported that, in obese patients, the main effect of increased adiposity and adipocytes stress is a low grade inflammation and its most probable outcome is insulin resistance; this pattern is widely observed in clinical populations (Belkina *et al.,* 2010).

Increasing evidence suggest that increased release of tumour necrosis factor-α (TNF-α), interleukin-6 (IL-6), monocyte chemoattractant protein-1 (MCP-1) and additional products of macrophages and other cells that populate adipose tissue have a role in the development of insulin resistance (Wellen *et al.,* 2005; Fain *et al.,* 2004). Although the exact causes of insulin resistance are not completely understood, scientists think the major contributors to insulin resistance are excess weight and physical inactivity. There is strong evidence that physical activity about the role of acute or chronic exercise on cytokines and insulin resistance in males with obesity or chronic diseases. There are limited studies in these regard on obese or overweight women and future studies will be needed to address the relative importance of exercise training on glucose homeostasis in this population. In this study, we aimed to clarify aerobic training effects on insulin resistance and glucose profile in adult obese women.

Materials and methods

Subjects included thirty non-trained healthy obese men (aged 38 +/- 4.8 years, body weight 82.5 +/- 7.9 kg) that divided to exercise (participate in aerobic exercise program) and control (no training) group. This study was aimed to investigate the effect of a three months aerobic training on glucose profile and insulin action in obese women. All subjects gave their informed consent to participate in the study, which was approved by the Ethics Committee for Islamic Azad University, Iran. Participants were non-athletes. Subjects were non-smokers and had not participated in regular exercise/diet programs for the preceding 6 months. Those with type 2 diabetic and other chronic diseases were excluded from the study. In addition, exclusion criteria included supplementations that alter carbohydrate or fat metabolism.

Exercise protocol and measurements

Exercise program lasted 12 weeks at 60-80(%) of maximal heart rate. Each session lasted 30-45 min. Exercise session was 3 times to week consist of running or pedaling on stationary cycle. Each session started by 15 min of flexibility exercises, 30-40 min of aerobic exercise and 5–10 min of cool down activity.

All anthropometric measurements were made by the same trained general physician and under the supervision of the same pediatrician following standard protocols. The weight and height of the participants were measured in the morning, in fasting condition, standing when the participant had thin clothes on and was wearing no shoes by using the standard laboratory scales. The Body Mass index (BMI) was calculated using the formula body weight/height2 in terms of kg/m². Visceral fat and body fat percentage was determined using body composition monitor (OMRON, Finland). All measurements repeated after exercise program.

48 h before and after the aerobic training, fasting glucose and serum insulin were measured. All blood samples were collected after overnight fast between 8

a.m to 9 a.m. Blood samples were dispensed into EDTA-coated tubes and centrifuged for 10 minutes in order to separate serum. Serums stored at -80° until the assays were performed. Fasting blood glucose concentration was measured by the glucose oxidase method (Pars Azmun. Tehran, Iran). The sensitivity of the insulin assay was 1.76 PIU/mL. Intra and inter-assay coefficients of variation were 2.6 and 2.88%, respectively. The homoeostasis model assessment (HOMA) for estimating insulin resistance was calculated as serum glucose (mmol/L) × serum insulin (mU/L)/22·5 (Duncan *et al.,* 1995).

Statistical analysis

After assessment of the normal distribution by the Kolmogorov-Smirnov test, differences between groups were calculated using the independent samples t-test. Student's t-tests for paired samples were performed to determine significance of changes in variables by exercise test in studied subjects. An alpha-error below 5% was considered as statistically significant.

Results

Anthropometrical and blood chemistry parameters during experimental protocol are shown in Table 1. Participant characteristics are reported as means ± SD. No baseline differences were found between groups for any biochemical or physical parameters (see table 1). Based on Paired T test data, all anthropometrics and biochemical variables improved after the therapy in exercise group.

Table 1. Pre and post training values of anthropometrical and clinical markers in two groups.

Parameter	Exercise		Exercise	
	Pretraining	post-training	Pretraining	post-training
Age (year)	38 +/- 4.8	38 +/- 5.1	39.5 +/- 5.3	39.5 +/- 6.3
Height (cm)	160 +/- 7.8	160 +/- 7.2	163 +/- 7.3	163 +/- 6.4
Weight (kg)	82.5 +/- 7.9	80.5 +/- 6.7	86.7 +/- 5.9	87.2 +/- 6.9
Abdominal to hip ratio	0.97 +/- 0.06	0.97 +/- 0.04	0.96 +/- 0.011	0.97 +/- 0.03
BMI (kg/m2)	32.1 +/- 3.4	31.3 +/- 3.3	32.9 +/- 3.1	32.82 +/- 3.56
Body fat (%)	45.7 +/- 6.3	44.3 +/- 5.2	41.5 +/- 5.8	41.8 +/- 6.11
Visceral fat	8.47 +/- 2.1	8.4 +/- 1.90	8.75 +/- 2.1	8.9 +/- 2.11
Glucose (mm/L)	93 +/- 14	81 +/- 11	90 +/- 11	93 +/- 9.1
Insulin (μIU/ml)	7.23 +/- 2.03	5.76 +/- 1.11	8 +/- 2.12	8.2 +/- 1.9
Insulin resistance (HOMA-IR)	1.63 +/- 0.23	1.14 +/- 0.16	1.85 +/- 0.36	1.88 +/- 0.34

Compared to pre-training, body weight, body mass index, body fat percentage and the other anthropometrical indexes decreased significantly by exercise program in exercise group but not in the control groups. Also Exercise training resulted in significant decrease in fasting glucose level in exercise group ($p = 0.033$). With aerobic exercise training, we also observed that insulin resistance in exercise subjects decreased significantly ($p = 0.019$), but remained without change in control group. Interestingly, Concentrations of serum insulin significantly decreased in exercise group ($p = 0.014$).

Discussion

Previous investigations have described a negative association between the level of daily physical activity and the incidence of type 2 diabetes (Wei *et al.,* 1999; Manson *et al.,* 1992). In line with these studies, main results of present studies were significantly decrease in some type II diabetes determinates in adult obese men. On the other hand, aerobic training in 12 weeks decreases fasting glucose and insulin resistance in studied subjects. Aerobic program was also associated with serum insulin.

It has been demonstrated that some Asian ethnicities, do not produce sufficient insulin secretion when

insulin resistance is elevated by the increased consumption of fat and simple sugars associated with Western dietary habits (Cockram, 2000). It has been established that high fat diet increased peripheral insulin resistance, whereas exercise training reversed this condition. In addition to modulating insulin resistance, exercise training, in addition to decreasing insulin resistance also affected ß-cell function and mass. Indeed, both high fat diet and exercise increased insulin secretion and ß-cell mass; however, the mechanism of each was independent from the other (Park *et al.,* 2007).

It is important to make a note here that at the cellular level, increased insulin resistance is associated with alteration in the insulin signaling way, reduction of the GLUT4 glucose transporter expression or alteration in the GLUT4 translocation to the plasmatic membrane of adipose and muscular cells, which ultimately leads to lower biological activity of the hormone, disturbing the glucose homeostasis (Shulman, 2000; Machado *et al.,* 2006). There is some evidence that exercise improves glucose concentration by increasing glucose uptake in skeletal muscle and adipose tissues (Berggren *et al.,* 2005; Corcoran *et al.,* 2007; Holloszy, 2005). On the other hand, recent experimental investigations have reported that exercise training enhanced hepatic insulin signaling by suppressing hepatic glucose output during hyperinsulinemic clamp states (Heled *et al.,* 2004; Perseghin *et al.,* 2007). Aerobic training in present study has also decrease body weight, body mass index and body fat percentage in studied subjects. In this regard, some recently published research studies have reported exercise training program involved aerobic training reduces the amount of visceral fat mass and body weight without decreasing lean body mass and it also ameliorates insulin sensitivity and blood glucose levels. In response to prolonged exercise, not only insulin resistance but also glucose-stimulated insulin secretion plays important roles in regulating glucose homeostasis (Kaastra *et al.,* 2006; Urano *et al.,* 2004).

Since the main mechanism responsible for the increased insulin resistance and glucose are not yet fully understood, provide a possible mechanism responsible for the loss of these variables in response to a three-month training program in the present study is difficult and controversial. But based results of similar studies about the effects of exercise training on these variables other obese or diseases population, changes in the variables in the present study may be mediated by other hormonal changes such as inflammatory or non-inflammatory response to exercise program. Although in present study, the lack measuring of peptide mediators such as interleukin or adiponectin are main limitations, but other studies on type II diabetes showed high significant association between the changes in cytokines with fasting glucose or insulin resistance (Tang *et al.,* 2005; Sheu *et al.,* 2008). For example, previous studies have pointed that decreased fasting glucose and insulin resistance is associated with improved serum adiponectin or leptin in response to different exercise programs in obese or type II diabetes subjects (Lara-Castro *et al.,* 2006; Brooks *et al.,* 2007; Imbeault, 2007).

References

Belkina AC, Denis GV. 2010. Obesity genes and insulin resistance. Current Opinion in Endocrinology, Diabetes and Obesity. **17(5),** 472-7. http://dx.doi.org/10.1097/MED.0b013e32833c5c48

Berggren JR, Hulver MW, Houmard JA. 2005. Fat as an endocrine organ: influence of exercise. Journal of Applied Physiology **99,** 757–764. http://dx.doi.org/10.1152/japplphysiol.00134.2005

Brooks N, Layne JE, Gordon PL, Roubenoff R, Nelson ME, Castaneda-Sceppa C. 2007. Strength training improves muscle quality and insulin sensitivity in Hispanic older adults with type 2 diabetes. International Journal of Medical Sciences **4(1),** 19–27. http://dx.doi.org/10.7150/ijms.4.19

Cockram CS. 2000. The epidemiology of diabetes mellitus in the Asia-Pacific region. Hong Kong Medical Journal **6,** 43–52.

Corcoran MP, Lamon-Fava S, Fielding RA. 2007. Skeletal muscle lipid deposition and insulin resistance: effect of dietary fatty acids and exercise. American Journal of Clinical Nutrition **85,** 662–677.

DeFronzo RA, Bonadonna RC, Ferrannini E. 1992. Pathogenesis of NIDDM: a balanced overview. Diabetes Care **15,** 318–353.
http://dx.doi.org/10.2337/diacare.15.3.318

Duncan M, Singh B, Wise P. 1995. A simple measure of insulin resistance. Lancet **346,** 120–1.
http://dx.doi.org/10.1016/S0140-6736(95)92143-5

Fain JN, Madan AK, Hiler ML, Cheema P, Bahouth SW. 2004. Comparison of the release of adipokines by adipose tissue, adipose tissue matrix, and adipocytes from visceral and subcutaneous abdominal adipose tissues of obese humans. Endocrinology **145,** 2273–2282.
http://dx.doi.org/10.1210/en.2003-1336

Heled Y, Shapiro Y, Shani Y, Moran DS, Langzam L, Barash V, Sampson SR, Meyerovitch J. 2004. Physical exercise enhances hepatic insulin signaling and inhibits phosphoenolpyruvate carboxykinase activity in diabetes-prone Psammomys obesus. Metabolism **53,** 836–841.
http://dx.doi.org/10.1016/j.metabol.2004.02.001

Holloszy JO. 2005. Exercise-induced increase in muscle insulin sensitivity. Journal of Applied Physiology **99,** 338–343.
http://dx.doi.org/10.1152/japplphysiol.00123.2005

Imbeault P. 2007. Environmental influences on adiponectin levels in humans. Applied Physiology, Nutrition, and Metabolism **32(3),** 505-11.
http://dx.doi.org/10.1139/H07-017

Kaastra B, Manders RJ, Van Breda E, Kies A, Jeukendrup AE, Keizer HA, Kuipers H, Van Loon LJ. 2006. Effects of increasing insulin secretion on acute postexercise blood glucose disposal. Medicine Science and Sports Exercise **38,** 268–275.
http://dx.doi.org/10.1249/01.mss.0000183875.86476.bd

Kahn SE. 2001. The importance of β-cell failure in the development and progression of type 2 diabetes. Journal of Clinical Endocrinology & Metabolism **86,** 4047–4058.
http://dx.doi.org/10.1210/jc.86.9.4047

Lara-Castro C, Luo N, Wallace P, Klein RL, Garvey WT. 2006. Adiponectin multimeric complexes and the metabolic syndrome trait cluster. Diabetes **55(1),** 249-259.
http://dx.doi.org/10.2337/diabetes.55.01.06.db05-1105

Machado UF, Schaan BD, Seraphim PM. 2006. Transportadores de glicose na síndrome metabólica. Arquivos Brasileiros de Endocrinologia & Metabologia **50,** 177-89.
http://dx.doi.org/10.1590/S0004-27302006000200004

Manson JE, Nathan DM, Krolewski AS, Stampfer MJ, Willett WC, and Hennekens CH. 1992. A prospective study of exercise and incidence of diabetes among United States male physicians. Journal of the American Medical Association **268,** 63–67.
http://dx.doi.org/10.1001/jama.268.1.63

Park S, Hong SM, Lee JE, Sung SR. 2007. Exercise improves glucose homeostasis that has been impaired by a high-fat diet by potentiating pancreatic B- cell function and mass through IRS2 in diabetic rats. Journal of Applied Physiology **103(5),**1764-71.
http://dx.doi.org/10.1152/japplphysiol.00434.2007

Perseghin G, Lattuada G, De Cobelli F, Ragogna F, Ntali G, Esposito A, Belloni E, Canu T, Terruzzi I, Scifo P, Del Maschio A, Luzi L. 2007. Habitual physical activity is associated with intrahepatic fat content in humans. Diabetes Care **30,** 683–688.
http://dx.doi.org/10.2337/dc06-2032

Sheu WH, Chang TM, Lee WJ, Ou HC, Wu CM, Tseng LN ET AL. 2008. Effect of weight loss on proinflammatory state of mononuclear cells in obese women. Obesity (Silver Spring) **16(5),** 1033-8.
http://dx.doi.org/10.1038/oby.2008.37

Shulman GI. 2000. Cellular mechanisms of insulin resistance. Journal of Clinical Investigation **106,** 171-6.
http://dx.doi.org/10.1172/JCI10583

Tang Z, Yuan L, Gu C, Liu Y, Zhu L. 2005. Effect of exercise on the expression of adiponectin mRNA and GLUT4 mRNA in type 2 diabetic rats. Journal of Huazhong University of Science and Technology. Medical sciences **25(2),** 191-3.
http://dx.doi.org/10.1007/BF02873574

Urano Y, Sakurai T, Ueda H, Ogasawara J, Sakurai T, Takei M, Izawa T. 2004. Desensitization of the inhibitory effect of norepinephrine on insulin secretion from pancreatic islets of exercise-trained rats. Metabolism **53,** 1424–1432.
http://dx.doi.org/10.1016/j.metabol.2004.06.008

Wei M, Gibbons LW, Mitchell TL, Kampert JB, Lee CD, and Blair SN. 1999. The association between cardiorespiratory fitness and impaired fasting glucose and type 2 diabetes mellitus in men. Annals of Internal Medicine **130,** 89–96.
http://dx.doi.org/10.7326/0003-4819-130-2-199901190-00002

Wellen KE, Hotamisligil GS. 2005. Inflammation, stress, and diabetes. Journal of Clinical Investigation **115,** 1111–1119.
http://dx.doi.org/10.1172/JCI25102